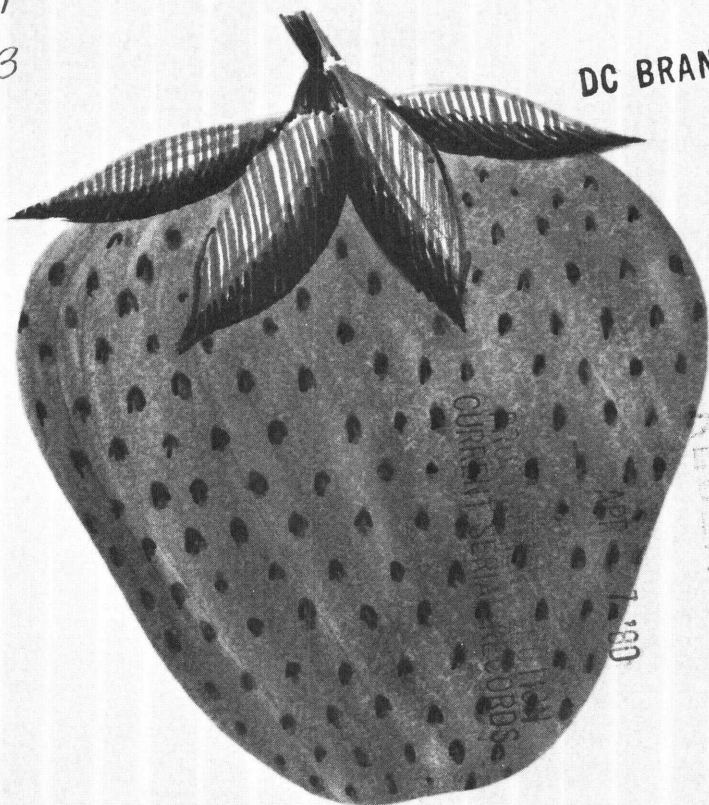


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CURRENT STRAWBERRY RECORDS

COMMERCIAL STRAWBERRY GROWING IN THE PACIFIC COAST STATES

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COMMERCIAL STRAWBERRY GROWING IN THE PACIFIC COAST STATES

By GEORGE F. WALDO, *horticulturist,¹ Plant Science Research Division, Agricultural Research Service*, and ROYCE S. BRINGHURST, *geneticist*, and VICTOR VOTH, *horticulturist, Division of Pomology, California Agricultural Experiment Station*

Strawberries are grown throughout the Nation; extensive commercial production is confined, however, to a few States. Approximately 65 percent of strawberry production in the United States is on the Pacific Coast.

High yielding varieties, favorable climatic conditions, and improved farming methods have enabled the Pacific Coast to maintain its position as a leading strawberry growing area in the United States. Rapid air and rail transportation makes it possible for shippers to supply eastern markets with fresh strawberries throughout the summer.

Before you decide to grow strawberries commercially, make sure that—

- Market outlets are available in the area.
- Labor is available during the harvest season.
- The acreage you intend to plant is large enough to make the enterprise profitable.

- The costs of the operation will not be too high. Some of these costs are for equipment, fertilizer, soil fumigation, irrigation, supplies, wages and transportation for pickers, and control of insects and diseases.

GROWING AREAS

Strawberries are grown under many different climatic and soil conditions in the Pacific Coast States. The characteristics of the different growing areas are as follows.

California

In all California areas, strawberries are grown under the hill system on soils fumigated with chloropicrin-methyl bromide mixtures. Most plants are taken from the nursery about January and kept in cold storage at 28° to 30° F. until they are set in the fields in summer. First-year production is very heavy and the fruit quality is good.

¹ Retired.

In warm-winter locations on the coast, fields are planted in winter as well as in summer with plants freshly harvested from nurseries at high elevations of about 3,000 feet. Some varieties also benefit from 2 to 3 weeks of cold storage at 32° to 36° F. The fruit from winter plantings is produced very early, but yields are substantially less than yields from summer plantings. With both planting systems, the precise planting time is determined by the location and the variety.

Summer plantings usually are sprinkler irrigated during most of the first year to keep salt from accumulating. During the fruiting season they are furrow irrigated. Generally, all plantings are mulched with clear polyethylene to speed up ripening, reduce fruit rot, and help maintain surface soil moisture.

Central Coast

This area includes Santa Cruz, Monterey, and Santa Clara Counties. In general, the central coast has warm winters and cool summers. The plants do not produce runners after the first year partly because of the warm winters. Harvest begins in April and continues until stopped by rain, usually in November.

Shasta was the principal variety for many years but it is giving way to higher yielding, firmer fruited Tioga. The patented private variety, Goldsmith, has been partly replaced by another private variety, Ned's Pride. Shasta, Tioga, and Ned's Pride are summer planted beginning about August 1.

Goldsmith is winter planted. Fruit from all varieties is harvested for one or two seasons.

Two-spot spider mites are the most damaging pests in the area, particularly on the very susceptible Shasta variety. Losses from virus diseases usually are minor because the nursery stocks are of high quality and the life of the plants is short. During wet years, red stele root rot damages some plantings on poorly drained soils.

About 75 percent of the central coast fruit is marketed fresh and the rest is processed in the frozen pack.

Central Valleys

This small but prosperous production area is located near Fresno. Winter temperatures are much colder and summer temperatures are much warmer than those on the coast. The harvest season begins in April and lasts about 2 months.

The principal variety is Tioga, but some Fresno is planted.

All plantings are made from early to mid-July from cold storage plants. Fruit is harvested for 1 year only.

Santa Maria

This area includes Santa Barbara and San Luis Obispo Counties. In general, winter temperatures are warmer than those of the central coast, but summer temperatures are about the same.

Harvest begins in April and continues through the summer and fall until stopped by rain. Slightly more than half the fruit is mar-

keted fresh. The rest is sold to the frozen fruit market.

The principal varieties are Tioga, Fresno, Goldsmith, and Ned's Pride. Plants are set in both winter and summer, and fruit is harvested for 1 or 2 years.

Southern California

This area includes the Oxnard coastal plain of Ventura County and the coastal regions of the counties of Los Angeles, Orange, and San Diego.

The principal varieties are Tioga and Fresno. About 65 percent of the acreage is planted in summer and the rest in winter. Tioga is the principal winter-planted variety; but some Sequoia, Fresno, and Torrey are winter planted also.

Plants are harvested for only 1 year and then new plants are set. Wherever new strawberry plants are set each year, winter plantings are alternated with summer plantings.

The harvest of winter plantings begins in February and ends in June, except that harvest of the new Sequoia variety may begin in January. In summer plantings, harvest begins in March and ends in July or August. Most of the fruit is marketed fresh, but 25 percent or more may be sold for processing.

Oregon

Northern Willamette Valley

This area has the largest acreage of strawberries of any part of the United States. The harvest begins in late May and continues until early July.

Most of this area has heavy rainfall during winter and little or no rain from June to September. Rains begin earlier and continue later in the foothills of the Cascade Mountains than in the valley. Winter temperatures are colder than in California strawberry growing areas.

High humidity in the hill areas of the Willamette Valley reduces loss of soil moisture. Deep rooting varieties such as the Marshall can be grown without irrigation.

Almost all irrigation in the valley is with sprinkler systems.

Strawberries are grown on the red hills bordering the valley up to elevations of 2,000 feet. Water for irrigation usually is not available at higher elevations.

The principal varieties are Hood, Northwest, Marshall, and Siletz. Large processing plants are located in the area, and about 95 percent of the crop is processed by freezing.

Red stele root rot causes damage in some heavy soils, and virus diseases are serious.

Hood River Valley

This area is on the Columbia River in the Cascade Mountains. The climate is similar to the Willamette Valley except there is less winter rainfall, and temperatures are colder in the winter. Strawberry plants are covered with snow in the higher altitudes in winter.

All strawberries are grown for freezing. The principal varieties are Northwest, Hood, and Marshall. Both furrow and sprinkler irrigation systems are used. Harvest begins in June and continues until mid-July.

Washington

Southwestern Washington

This area includes Clark and Lewis Counties. The climate is similar to the northern Willamette Valley.

Soils in this area are variable, but many are similar to the red hill soils in Oregon. Sprinkler irrigation is used during summer. The Northwest is the principal variety.

Harvest begins in June and continues until mid-July. The berries are grown for the frozen fruit market.

Puget Sound Region

The main strawberry producing area in Washington is the Puget Sound region, which extends from Olympia north to the Canadian border. Most of the acreage is in Snohomish, Skagit, and Whatcom Counties. Climatic conditions are similar to those in Oregon, except in Whatcom County where severe winter temperatures cause injury in some years.

Northwest is the principal variety. Puget Beauty and Columbia have been grown in recent years by a few growers. The harvest season begins in early June and lasts until mid-July. Sprinkler irrigation is used in summer.

Red stele root rot causes little damage, but virus diseases sometimes are serious.

Eastern Washington

Commercial strawberry growing is not extensive in eastern Washington, but some berries are grown

for local markets in Walla Walla and Spokane Counties.

Winter temperatures are colder and spring temperatures are warmer than in western Washington. Irrigation is necessary.

Shasta and Northwest are the principal varieties. The harvest season begins in early June and lasts until mid-July.

MARKET OUTLETS

Market outlets and transportation facilities should be available in growing areas. Facilities for the distribution of fresh strawberries are established in the California producing areas, and processing plants for frozen strawberries are located in California and the Pacific Northwest.

The established market outlets are individual buyers, food processing companies, and grower cooperatives. Independent dealers usually pay for the fruit immediately following harvest, but grower cooperatives often withhold payment until the crop is sold and all expenses paid. Many of the market outlets sell growers strawberry plants, fertilizers, spray materials and dusts, harvesting supplies, and specialized equipment. They also supply growers with information on all phases of strawberry growing.

VARIETY SELECTION

The recent increase in strawberry production in the Pacific Coast region is due largely to the origination of especially adapted varieties.

THE STRAWBERRY PLANT

The strawberry plant grows from a central stem called a crown whose terminal is a growing point. From this growing point leaves, flowerbuds, and runners develop. Runners are branches from the main stem. Branch crowns may develop following rapid runner development.

Buds in the axils of the leaves produce flower clusters when temperatures are cool and days are relatively short. Different varieties tend to produce clusters of a particular type. Thus, some varieties produce clusters with many flowers, while others produce clusters with few flowers. Some varieties produce clusters that branch close to the crown while others branch far out on the stem. Clusters with many flowers may produce a large number of berries but the berries may be small.

Strawberry varieties grown commercially in the Pacific Coast States are known as the spring, or June, bearing varieties. They produce flowerbuds in late summer or autumn and then flower and fruit the following spring.

The first varieties grown on the Pacific Coast came from the East, but the varieties now grown extensively in the Pacific Coast States originated there.

You should grow varieties that are resistant or tolerant to diseases prevalent in the area, particularly virus diseases, which are widespread along the Pacific Coast.

When you grow such tolerant varieties as Shasta and Northwest, they remain productive over a longer period than susceptible varieties.

Red stele is a serious root rot disease in areas of high winter rainfall. Varieties with some resistance are Siletz, Hood, Puget Beauty, and Columbia. Mildew and leafspot also cause damage in wet climates; resistant varieties are Hood, Northwest, Siletz, and Shasta.

The varieties grown in California are largely for fresh market. The berries must be uniform, attractive, firm enough for shipping, large, and of good dessert quality. Usually, the large fruit is sold fresh and the small fruit goes to the freezer, but the difference between the price of fresh fruit and frozen fruit often determines where the fruit is sold.

In Oregon and Washington, the main market outlets are for frozen strawberries. Berry size is not important in the frozen pack since the market prefers medium and small fruit. However, small-sized fruit is expensive to harvest.

In California, where strawberries are harvested throughout the growing season, select a variety that will give high production during the entire period. In the Pacific Northwest, where the fruiting season is short, production usually lasts only about 3 to 6 weeks. In both areas, the variety you select should give large total production during the harvest period.

In the Northwest, early flowering varieties often are injured by late

spring frosts. Midseason varieties, therefore, are considered more reliable.

Many varieties, such as Siletz, produce many berries on a single flower cluster. The first two or three berries normally are large and the rest small. Varieties of this type usually produce a high percentage of berries that are too small to sell even though the total yield often may be very high.

Some varieties, particularly those with a long harvest period such as Shasta and Marshall, do not have many berries per cluster but they are usually large.

You must depend on varieties that are adapted to your area. No single variety has proved satisfactory over a large area, and even those that are best adapted have some serious weaknesses. Study the varieties grown in your area and select the one that best suits your operation.

The principal varieties grown in California are Tioga, Fresno, Shasta, Goldsmith, and Ned's Pride.

Varieties grown in Oregon and Washington are Marshall, Northwest, Siletz, Cascade, Columbia, Hood, and Puget Beauty. About 80 percent of the acreage in Oregon and Washington is planted in the Northwest variety.

For a description and discussion of varieties, see Farmers' Bulletin 1043, "Strawberry Varieties in the United States." Ask your county agricultural agent for a free copy or write to the Office of Information, U.S. Department of Agriculture, Washington, D.C. 20250.

Send your request on a post card. Include your ZIP Code.

SUITABLE SITES

Gentle slopes are best for strawberries because they provide good water drainage and air movement. Drainage may not be satisfactory on level land. On slopes that are too steep, however, soil erosion can be serious and cultivation expensive.

Although soil moisture may be more uniform and the soil deeper in low areas, cold air settles there and frosts can cause severe damage. Hilltop soils are often thin, lacking in fertility, and exposed to wind that causes the soil to dry out quickly. Also, plants on hilltops are more likely to be injured by cold north winds in winter.

Strawberries on northern slopes ripen later than those on southern slopes, but the yields on northern slopes may be much larger. This is because northern slopes are cooler and provide more uniform moisture and usually have deeper soil.

Areas that are surrounded by trees or buildings may not have good air movement. Diseases may be serious in such places, and frosts may injure blossoms on cold nights in spring.

You can grow strawberries on many different soil types. Certain varieties may be well adapted to heavy clay soil while others grow well on light, sandy soil if it is fertile. Generally, however, strawberries grow best on fertile, well-drained, slightly acid, loam soils.

Slightly acid soils are common

in the strawberry growing regions of Oregon and Washington but not so common in California. Salinity often is a problem in areas of California and eastern Oregon and Washington that have low rainfall and poor drainage.

The alluvial soils of river valleys are suitable for strawberries if located where flooding does not occur. These soils are usually deep, easy to work, and well drained. Many strawberries also are grown on the red hill soils bordering the valleys in Oregon and Washington. Some of these soils lose their fertility rapidly. Do not plant strawberries on poorly drained heavy soil, light sandy or gravelly soil that is not fertile, or thin soil underlaid with rock.

PREPARING THE SOIL

In many areas, particularly in the Northwest, continuous cropping has depleted the soil of plant nutrients and organic matter and has left the soil in poor physical condition. A hardpan, or plow sole, often develops just below the level of cultivation. Often you must give these old cultivated soils a program of soil improvement to increase the organic matter and make plant nutrients available.

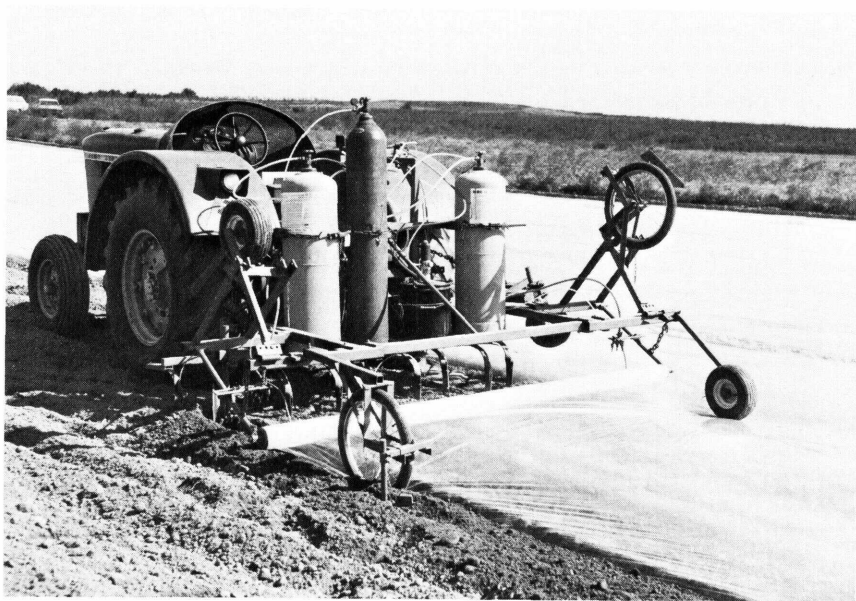
The use of barnyard manure is one of the quickest and most effective ways of improving soil for strawberries. Applications of from 10 to 40 tons of manure per acre usually are effective. You also may use poultry manure but at a lower rate. Whenever manure is available, you should use it in preparing soil for strawberries.

Some growers have objected to the use of manure because of infesting the soil with weed seeds. This objection is partly overcome by the use of chemicals for weed control. Practically all growers in Washington and Oregon use chemicals for weed control; all growers in California use them. These chemicals must be used with care under a polyethylene bed mulch.

Grasses and meadow crops are probably the most effective means of increasing organic matter in soil. The grass roots penetrate the soil thoroughly and deeply, and after the grass grows for 3 to 5 years, a good sod develops. When you plow this sod under, it improves the physical condition of the soil by distributing organic matter throughout the plow layer. In many parts of the West, alfalfa, clover, and other legumes have been used. Plowing under vetch, oats, rye, wheat, barley, sudangrass, or peas has been effective. When the soil is poor, you may need to plow under two or three such crops before strawberries are planted.

Plow the soil carefully before planting. Plow deeply and work the soil thoroughly with a disk so large air spaces will not be left. If the soil is very loose, you may need to lightly roll or pack it so you can set the plants firmly. Prepare the soil as thoroughly as you would for grain or vegetables.

You must prepare the soil thoroughly for fumigation to control diseases and soil insects, particularly symphyllans in Oregon and Washington. The fumigant must penetrate the soil thoroughly



BN-31251

Methyl bromide and chloropicrin fumigant is applied under a polyethylene tarp in California.



BN-31257

Effect of fumigation of the soil on the growth of strawberry plants: Left, fumigated; right, not fumigated.



BN-31255

Equipment used in Oregon to fumigate strawberry plantings for symphylan control.

or it will not kill symphylan organisms.

You will need special equipment to apply the fumigants, usually a chisel type applicator. Since fumigation methods and materials are constantly changing, consult your county agricultural agent for information on fumigation practices.

Crop residues should be removed, burned, shredded, or worked into the soil. Subsoiling is usually necessary if the soil is heavy or a hardpan is present. The subsoiling should be done when the soil is dry. Following subsoiling, the soil should be thoroughly disked or rototilled.

Where furrow irrigation is used, as in California, the plants are set on raised beds with furrows between them. The soil must be absolutely level so water can run in

either direction in the furrows between the beds.

PLANTING SYSTEMS

In California, the most common method of planting is to set double rows of plants on raised beds. The beds are spaced about 38 to 44 inches from center to center. The rows in each bed are spaced 8 to 12 inches apart, and the plants in each row are set about 8 to 14 inches apart. Sometimes, single rows on raised beds are used. These beds are spaced 30 to 36 inches from center to center.

In summer plantings, double rows outyield single rows. This is because salt accumulates in the center of the beds, and the accumulation reduces yield more in single rows.



BN-31253

Systems of planting strawberries: Left, single row; right, double row.

In contrast, winter plantings in the single row system generally yield more than those in the double row system because more ground surface is exposed to the sun and the bed is warmer during the winter. Also salt accumulation is less because the plants are in the beds for a shorter time.

In the Pacific Northwest, growers use single rows on beds 39 to 42 inches apart with the plants 12 to 15 inches apart in the rows. This method produces high yields under irrigation, and it is less expensive than the double row system

for controlling runners and harvesting berries.

The table below gives the number of plants required per acre using the different planting distances. The double row system probably would not be used when beds are only 36 or 39 inches apart.

OBTAINING PLANTS

Plants used in commercial plantings on the Pacific Coast are grown in nurseries. The mother plants are set in the nursery in the spring to produce the young plants that are

Plants per acre at different planting distances

Spacing		Plants per acre	
Between beds (inches)	Between plants (inches)	Single row	Double row
36	12	14,520	—
36	15	11,616	—
39	12	13,403	—
39	15	10,993	—
42	8	18,699	37,398
42	10	14,966	29,932
42	12	12,446	24,892
42	14	10,662	21,324

dug in the fall or winter for sale to commercial growers. Diseases and insects must be controlled in the nurseries. Cold storage plants are used for summer plantings in California and they are generally used in Washington and Oregon. These plants must be dug while fully dormant in midwinter.

All nursery-grown plants are inspected and many are certified by State agencies as true to variety and free of diseases and insects. In Oregon and Washington, plants are sold in boxes of 1,000 and in California, in boxes of 1,000 to 2,000.

PLANTING

Planting requires careful attention to assure a full stand and subsequent large yields. At plant harvest, the leaves are removed before the plants are put in polyethylene lined containers for storage. If plants are to be set into the fruiting fields shortly after they are dug, as in California winter plantings, the young, partially expanded leaves should be left on the plants. If leaves are left on the plants, be sure the plants receive enough moisture after they are planted.

Many growers cut off the long roots about 4 inches below the crown to facilitate mechanized or semimechanized planting. This is an expensive practice, and there is no evidence that it is of any value to the plants.

Many large strawberry growers use planting machines. These machines set the plants at the proper distance apart and at the proper depth. Adjust the machines so that

plant roots are set well down into the soil and the soil is firmed against the crown at the ground line between the roots and leaves.



BN-31256

Setting strawberry plants with machines in the Pacific Northwest.

Only a furrowing disk that opens a narrow trench is used in California and the plants are set by hand.



BN-31254

Opening narrow trenches for setting strawberry plants by hand in California.

When you set the plants by hand, use a spade, shovel, or trowel to make an opening in the soil. Then set the strawberry roots well down into the opening. Press the soil firmly against the roots so they will not dry out and cause the plants



BN-31338

Planting strawberries by hand in narrow row trenches opened by machine in California.

to die. Do not cover the crown of the plant with soil.

Keep the plants moist during planting. When you take plants out of cold storage, plant them as soon as possible. If planting is delayed, put the plants back into cold storage. Irrigate immediately after planting. Moderate irrigation with sprinklers is the best method to give plants a good start. Sometimes growers apply fertilizer, particularly nitrogen, in the irrigation water.

In all areas of California, most strawberry varieties can be summer planted successfully by using cold storage plants. The time of planting is very important; 2 weeks too early or too late can make a crucial difference. Recommended timing ranges from early to mid-July in the central valleys to as late as mid-September for some varieties in southern California.

If you plant a variety too early, the plants will lack vigor, the fruit will be small, and the quality low. If you plant a variety late, the total yield will be small, although fruit size will be large and of good quality. And if you plant extremely

late, the plants develop runners as early as March during the fruiting season and produce very light crops.

In California's central coast and the Santa Maria and southern California areas, you may set plants successfully in the winter. However, only plants from high-elevation nurseries perform satisfactorily under this system. If grown at elevations of about 3,000 feet, they receive early seasonal chilling and will grow satisfactorily when winter planted. Also, for best results, apply clear polyethylene bed mulch immediately after planting.

Spring plantings are not recommended in California.

Spring is the usual time for planting in the Pacific Northwest. Plants usually are set in April or May, but occasionally plantings are made in February and March. When the spring weather has been cold, it may be necessary to set plants as late as June. When late plantings are made, irrigate the soil immediately to prevent plants from drying out.

Almost all strawberry plants set in the spring produce blossoms. Their removal stimulates growth. However, since this process is expensive, growers do not remove blossoms unless the weather is hot and dry.

When plants grow vigorously after spring planting, some growers find it profitable to pick and market the berries the first year. Some varieties in Oregon will occasionally fruit all summer and still grow vigorously and produce a full crop the following spring.

IRRIGATION

Almost all growing areas in California require frequent irrigation during the summer. The furrow system is used during fruit production. When sprinkler irrigation is used during fruiting, it stimulates fungus rot and makes the fruit unsuitable for shipping to the fresh market.

Salt accumulation is a serious problem in California soils, but this is minimized by sprinkler irrigation during the establishment period following planting. Salt must not be allowed to accumulate in the top inch of soil, because all new roots originate there.

With the furrow method, considerable effort and expense are needed to prepare the land for even distribution of the water. Land must be leveled, terraced, and ditched; plants are set on ridges with furrows between.

Under sprinkler irrigation, on the other hand, plants can be grown on rolling land where soils vary in depth. Since erosion is not as serious under sprinkler irrigation, light sandy soils can be used if they are fertile.

The sprinkler system is used in western Oregon and Washington. In this area, irrigation is needed only during the dry summer months. The furrow system is used in some areas of eastern Oregon and Washington.

In areas where the soil is sandy, frequent irrigation in summer is necessary, especially if the weather is warm and dry. The heavier soils of the Pacific Northwest usually do not need irrigating oftener than

every 2 or 3 weeks during the rainless period in summer. Enough water should be applied each time to thoroughly wet the soil through to the subsoil moisture. About 2 inches is usually sufficient for each application. Less water can be applied to sandy soils, but it should be applied more frequently and always following harvest.

WEED CONTROL²

Weed control is one of the most serious problems in strawberry production. Weeds compete with strawberries for sunlight, moisture, and nutrients; harbor insects, nematodes, and plant diseases; and interfere with fruit ripening and harvesting. Weeds must be controlled to prevent severe yield and quality losses.

Mechanical cultivation supplemented by hand-weeding is no longer practical to control weeds, but mechanical cultivation can be supplemented with herbicides. The use of black plastic mulch is effective in controlling weeds and fruit rot and in conserving moisture. Soil fumigation with methyl bromide or other soil fumigants before planting will control weeds and nematodes. In California, all soils are fumigated with methyl bromide-chloropicrin mixtures under polyethylene mulch.

Because of the many factors that influence the effective and safe use of herbicides, no specific recommendations for their use are given

² Prepared by L. L. Danielson, plant physiologist, Plant Science Research Division, Agricultural Research Service.

here. You can obtain specific information from your county agricultural agent or a weed specialist at your State experiment station.

Only a general reference is made to each herbicide and the rate and method of application that has proved useful in the Pacific Coast area. When using agricultural chemicals, follow the directions on the container label.

To control germinating annual broadleaf weeds and weed grasses in new plantings, you can apply a herbicide immediately after a clean cultivation in plantings established 2 weeks or more. The amount given for each of the following herbicides is the amount of active ingredient to apply per acre in 50 gallons of water: Chloroxuron, 4 pounds; DCPA, 6 to 9 pounds; or diphenamid, 4 to 6 pounds.

Herbicides applied too soon after planting often retard the root growth of the strawberry plants. Do not apply any herbicides within 60 days before harvest, during flowering, or during fruiting. Whenever you need to cultivate,

disturb only the surface inch or two of soil because strawberries are shallow rooted and deep cultivation destroys the roots. Make a herbicide application once after fall rains begin to control winter weeds.

Other herbicides such as simazine and sesone may be used for specific weed problems in some localities. The herbicide chosen for use in a field will depend on the kinds of weeds growing there.

Every effort should be made to lessen the need for herbicides by mechanical cultivation, mulching, and crop rotation.

FERTILIZERS

Although you should grow strawberries only on the most fertile soils, you still need to use some commercial fertilizer to obtain the highest yields. Soil tests and experience in growing are the best guides to fertilizer needs.

Strawberries grown in the Pacific Coast States usually respond to nitrogen fertilizers. California soils rarely need anything but nitrogen.

The common names and corresponding chemical names of the herbicides recommended for weed control are listed as follows:

<i>Common name</i>	<i>Chemical name</i>
chloroxuron	3-[<i>p</i> -(<i>p</i> -chlorophenoxy)phenyl]-1,1-dimethylurea
DCPA	dimethyl tetrachloroterephthalate
diphenamid	<i>N,N</i> ,dimethyl-2,2-diphenylacetamide
simazine	2-chloro-4,6-bis(ethylamino)- <i>s</i> -triazine
sesone	2-(2,4-dichlorophenoxy)ethyl sodium sulfate

Too much nitrogen causes excessive growth of foliage and runners. This, in turn, reduces yield. As you increase the nitrogen rate, the plants grow faster and the amount of phosphorus and potash they can obtain may become deficient.

The soils of Oregon and Washington are often deficient in other elements besides nitrogen. Phosphorus is often needed; potassium, sulfur, boron, and magnesium are sometimes needed. Lime is beneficial when the soil is very acid.

Do not apply nitrogen in the spring in Oregon and Washington unless the plants are weak and unless you know there is a deficiency. Nitrogen stimulates plant growth that makes the berries soft and lacking in flavor. Nitrogen is beneficial following harvest in Oregon and Washington and during July if the plants can be irrigated. If irrigation is not available, delay applying nitrogen until the fall rains begin.

You may apply phosphate fertilizers at planting time. To be effective, you should apply them in bands on both sides of the row 3 to 4 inches from the plants and 4 to 6 inches deep. You may broadcast boron and potassium fertilizers. Apply nitrogen as a urea spray or broadcast it in pellet form.

RUNNER CONTROL

In California, runners usually are easy to control when strawberries are bearing continuously all summer. The plants do not grow runners when they produce an abundance of fruit. Most varieties

produce runners on first-year summer plantings. The runners on these plants must be removed.

Runner control is difficult in the Northwest where fruit production lasts only a short period in the spring. When you use the matted bed system, plants often become too thick with runners, and yields are lowered. By reducing bed width to 8 to 12 inches with sharp disks, you get higher yields than in wide matted beds.

You can use spaced rows without much work if you grow a variety that does not produce many runners. Space the mother plants 15 to 18 inches apart and their runner plants 6 to 8 inches from each other and from the mother plants. Spaced rows may give very high yields.

Occasionally varieties are grown that produce large single plants but not many runners. Set the plants about 3 feet apart in each direction and cultivate in each direction. Many strawberry growers in the Northwest set plants 12 to 15 inches apart in a single row and cut off all runners. Since cutting runners by hand is expensive, growers use machines to throw the runners into the row and to cut them off.

CARE BEFORE HARVEST

If weeds and grass grow during the winter, remove them in the spring before picking begins. You can spray, dust, or bait with chemicals to control diseases and insects. Since chemicals and methods of applying them change from season

to season, you should see your county agricultural agent for information on their use.

Spring frosts can seriously damage strawberries in bloom. Usually, you can protect blooms from light frost damage by irrigating with sprinklers when temperatures are below freezing. Various types of orchard heaters have been used, but these are not as effective as with tree fruits.

HARVESTING

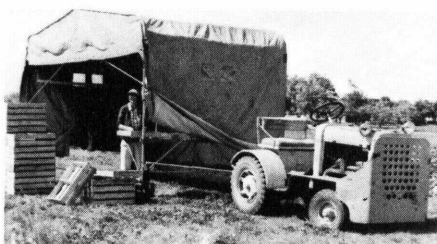
All strawberries are picked by hand. No machine is available commercially that can remove the berries from the plant at the right degree of ripeness without injuring them. In California, the stem is always removed completely. The only exception is when long stemmed fruit is picked for specialty sale. If you leave short stems, they puncture the soft fruit and expose the flesh to rot.

You must pick the berries at the



BN-31259

Picking strawberries by hand. Machines cannot be used.



BN-31260

A mobile berry shed where strawberries are collected in the field as they are picked.

right stage of ripeness. Overripe berries are soft and easily injured in marketing. Immature berries do not have good flavor and appearance.

Weather conditions usually determine the frequency of picking. Berries ripen fast in warm weather and slowly in cool weather. Normally, you should pick berries about every 4 or 5 days during the harvest season. Pick them early in the day. Berries are firmer and easier to handle when they are cool than when they are picked in the heat of the day.

In California, berries are picked for the fresh market or for freezing. Pickers are provided with a small cart on which to transport the berries in the field. Berries are harvested without caps for the



BN-31258

Cart used by pickers to transport strawberries in the field.

frozen fruit market and with caps for the fresh fruit market.

California berries picked for the fresh market are placed in cups of perforated plastic or fiberboard that hold up to 1 pound of fruit. Pickers carry the cups in trays that hold 12 cups. A tray usually contains 11 to 12 pounds of berries. Berries for the frozen fruit market are placed in wooden trays about the same size as those used for the fresh fruit market. Each tray holds about 15 pounds of fruit and no baskets are used.

In the Pacific Northwest, berries are harvested for the frozen fruit market. Pickers place them in cups (hallocks) of wood veneer or fiberboard containing about 1 pound of berries. They transport the berries in carriers holding six to eight 1-pound hallocks.

CARE AFTER HARVEST

In Oregon and Washington, removing the leaves immediately following harvest often increases yields the next year. Various means have been used, but a rotary mower is most satisfactory. Burning the leaves is a common practice. Chemical treatments are unsatisfactory because the crowns of the strawberry plants are often damaged.

The advantages of removing the leaves are that you can apply irrigation water more uniformly, and weed control and fertilizer application are easier. After you mow the plants they produce a quick, vigorous growth of new leaves needed for a good crop the following year.

You should not remove the

leaves from plants the first year in the Pacific Northwest.

When the matted row system is used, cut the width of the rows to 8 to 12 inches in late summer by using sharp disks or a rotovator.

During summer and autumn, plants should be irrigated, fertilized, and weeded. Growers in Oregon and Washington can often maintain high production for as many as four or five harvest seasons by using good postharvest practices. Most growers allow their fields to stay in production for at least three seasons. About one-third of the total acreage is replanted each year.

In summer plantings in California, remove the old leaves about January of the first winter just before you apply the polyethylene bed mulch. Do not disturb crowns and young leaves. Leaves are not removed from winter plantings, because all the leaves are new. After the first year, remove all the leaves during the winter if the plants are to be held for another harvest. Oil sprays are often used to kill the old leaves so they are easier to remove from old plantings.

Clear polyethylene bed mulch is essential to successful strawberry growing in California. It takes much of the gamble out of winter planting by increasing the soil temperature as much as 10° F. during the short winter days. Often this means the difference between vigorous growth and very little growth. When you use polyethylene, the fruit ripens earlier, the harvest is larger, and the harvest season is longer.

In winter plantings, apply clear polyethylene mulch immediately after planting. In summer plantings, do not apply the mulch until midwinter except when planting is late. Then you may apply it earlier. The benefits are somewhat the same as with winter plantings. In both cases, fruit quality is improved, harvesting is easier, and fruit rot damage is lessened. When you remove a planting from a field, remove the polyethylene. Do not cut it up and work it into the soil.

Always use clear polyethylene. Black polyethylene is unsatisfactory because it shades the soil and does not provide adequate midwinter heating of the soil, which promotes early bearing.

HOME GARDENS

Strawberries often are grown in home gardens for family use. The

practices used by commercial growers apply in general to home gardens. Many home gardeners have trouble growing strawberries because they are not familiar with soil and fertilizer requirements and with diseases and insects. Diseases and insects often give more trouble in home gardens than in commercial fields.

Many home gardeners grow everbearing varieties that fruit during the late summer months. These produce the best when plants are set out each spring and the blossoms removed up until July 1. By not allowing the first blossoms to develop fruit, the new plants rapidly build up for highest production during the rest of the summer.

In some areas of California, commercial varieties fruit all summer and home gardeners may use these as well as the everbearing varieties.



BN-31252

Applying clear polyethylene mulch in California to force early ripening. The leaves are pulled through slits cut in the plastic.

Even in Oregon and Washington, such varieties as Shasta will often fruit as satisfactorily as everbearers. Everbearing varieties that are usually satisfactory are Rockhill, Red Rich, Gem, and Mastodon.

The number of plants needed depends on the desires of the family. From 50 to 200 plants are enough for most families.

Home gardeners often find mulches convenient to keep down weeds and prevent the soil from washing onto the berries during irrigation. For this purpose, polyethylene is best; but sawdust, wood shavings, lawn clippings, or leaves also may be used.

DISEASES³

In selecting a soil for strawberry production, you should consider the crops that were previously grown on it. Some diseases that attacked the previous crop may also attack strawberries.

Root Diseases

Verticillium wilt organisms attack potatoes and tomatoes and will also attack strawberries. This disease has been very serious in California, and all land intended for strawberries must be fumigated before planting. Fumigate with chloropicrin and methyl bromide in combination under a polyethylene cover. Use up to 350 pounds per acre of 60 percent methyl bromide and 40 percent chloropicrin.

Verticillium wilt is also serious

in many areas of the Pacific Northwest; the fungus may attack strawberries following crops of black raspberries, hops, potatoes, and mint.

Because of its high cost, methyl bromide-chloropicrin fumigation is seldom used in the Pacific Northwest to control verticillium wilt in strawberry fields. Many growers avoid this disease by not planting strawberries on land with a history of verticillium infection. Because of the unusually high buildup of the fungus under potatoes and other verticillium sensitive crops in the Pacific Northwest, strawberries should not closely follow these crops without methyl bromide-chloropicrin fumigation.

Poorly drained, heavy clay soils may easily become infested with red stele root rot. This fungus spreads through the water in the soil during the rainy winter months. Red stele is especially serious in Oregon and Washington.

To avoid red stele, growers west of the Cascade Mountains in the Pacific Northwest usually do not plant on poorly drained heavy land. Often they set the plants on raised beds to improve drainage around the roots during the cold, wet winter months when the disease is active. Red stele is seldom serious east of the Cascade Mountains. Some varieties that are resistant to red stele are Hood, Siletz, Columbia, and Puget Beauty.

Foliage Diseases

Fungus diseases that damage leaves seldom cause serious damage in strawberries in the Pacific

³ Prepared by R. H. Converse, plant pathologist, Plant Science Research Division, Agricultural Research Service.

Northwest. Powdery mildew fungus can at times cause the leaves to curl, turn purplish, and become sparsely coated with a gray-white fungus growth.

Sulfur dusts or sprays or Karathane⁴ spray can be used to control powdery mildew if it threatens to damage the crop. Do not dust or spray in hot weather, because of possible plant damage. Karathane cannot be used closer than 21 days before harvest.

Bacterial leafspot is sometimes serious in California, especially where droplets of sprinkler irrigation water damage leaflets. Infected leaves are at first speckled on the undersides, by watersoaked spots that may later coalesce into large dead areas. There is no recommended control, but the disease is rare where furrow irrigation is used.

Fruit Rots

Gray mold fruit rot, or Botrytis fruit rot, causes major losses wherever strawberries are grown. The fungus-infected fruits develop a light brown, soft rot. As the fruit dries out, a gray, dusty fungus growth covers it. To reduce gray mold infection, space plants properly, avoid excessive vegetative growth, remove rot-damaged fruit when picking, and harvest all ripe fruit promptly.

⁴Trade names are used in this publication solely to provide specific information. Mention of a trade name does not constitute a guarantee of the product by the U.S. Department of Agriculture nor does it imply an endorsement by the Department over comparable products that are not named.

Spraying with fungicides such as captan, thiram, or Dyrene is often used to provide additional control. Since infection often begins at flowering, plants should be sprayed as blossoms open and again 7 to 10 days later. In wet seasons when rot may be severe, additional sprays should be applied at 7- to 10-day intervals. Follow the directions on the container label.

After the fruit is picked, prompt refrigeration at 32° to 50° F. retards rot. A temperature of 32° is more effective than higher temperatures.

Virus Diseases

Virus diseases are very widespread in the Pacific Northwest and seriously limit strawberry yields in that area. Several viruses usually act together to dwarf and weaken plants without producing symptoms. Many of these viruses are spread by strawberry aphids. For instructions on the control of aphids, see the section entitled "Insects."

Some methods for controlling strawberry virus diseases are:

- (1) Use such tolerant varieties as Northwest and Siletz.
- (2) Use certified planting stock. The best planting stock is grown in areas remote from cultivated strawberry fields.
- (3) Replant fruiting fields often.
- (4) Isolate new plantings. New plantings should be as far away as possible from old strawberry fields. One-half mile may be far enough to considerably reduce virus infection in California.

NEMATODES⁵

Strawberries are attacked by several kinds of nematodes, but the most damaging are the root-knot (*Meloidogyne hapla*) and root-lesion (*Pratylenchus* spp.). Other root feeding nematodes that occur frequently but cause less damage are the stubby-root (*Trichodorus* spp.), ring (*Criconemoides* spp.), lance (*Hoplolaimus* spp.), and dagger (*Xiphinema* spp.). Bud and leaf nematodes (*Aphelenchoides fragariae*) occasionally attack strawberries and cause the disease known as spring crimp or red plant.

Frequent culture of strawberries usually increases nematode damage. Crop rotations and fallowing the land aid in controlling nematodes.

All nematodes cause reduced fruit yield, plant damage, poor stands, and inefficient use of fertilizer and soil water. Root feeding nematodes increase the damage from several plant diseases, particularly verticillium wilt.

Root-knot nematodes cause small knots on the roots that are usually less than one-eighth inch in diameter. In older infections, the knots begin to decay, the root system is greatly reduced, and the roots often appear matted.

Root-lesion nematodes are common in most strawberry fields, but damage is frequently unrecognized. In heavy infestations, the roots be-

come infected with other microorganisms and root decay is extensive.

Bud and leaf nematodes enter the developing buds from the soil early in the growing season. Plants become dwarfed and leaves are small, narrow, crinkled, and dark colored or reddish. Many severely damaged plants die.

All soil-inhabiting nematodes can be controlled with nematicides and soil fumigants. Nematodes in roots, leaves, and buds can be killed by the hot-water treatment of plants; immerse the plants in water at 127° F. for 2 to 5 minutes.

Nematodes, diseases, and weeds can be controlled by treating the soil with methyl bromide (MBR); a mixture of dichloropropene and methylisothiocyanate (DD-MENCS); sodium methyldithiocarbamate (SMDC); a mixture of chloropicrin and DD; a mixture of chloropicrin and methyl bromide; or chloropicrin alone. Equally as good—but for nematodes alone—are materials containing dichloropropenes (DD or 1,3-D); materials containing ethylene dibromide (EDB); or dibromochloropropane (DBCP).

All the nematicides can be used to treat the soil before strawberries are planted but DBCP is the only one that can be used both before or after. However, control is more effective when treatments are used before planting.

When you use nematicides, carefully follow the instructions on the container label.

⁵ Prepared by J. M. Good, nematologist, Plant Science Research Division, Agricultural Research Service.

INSECTS⁶

Many insects damage strawberries by feeding on leaves, flowers, and fruits or by transmitting diseases. Aphids, spider mites, and weevils are serious pests of strawberries. Aphids and spider mites may be controlled with demeton

⁶ Prepared by Entomology Research Division, Agricultural Research Service.

and most weevils with chlordane. Follow the directions and precautions on the container label. For further information on insect pests of strawberries, see Farmers' Bulletin 2184, "Strawberry Insects—How to Control Them." You can get a free copy from your county agricultural agent or write to the Office of Information, U.S. Department of Agriculture, Washington, D.C. 20250.

PRECAUTIONS

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or

gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary landfill dump, or crush and bury them in a level, isolated place.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations.